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U. S. DEPARTMENT OF AGRICULTURE,
WEATHER BUREAU.
BULLETIN No. 6.

THE DIURNAL VARIATION OF BAROMETRIC PRESSURE.

BY

FRANK N. COLE, Ph. D.,
Assistant Professor of Mathematics, University of Michigan.

Published by authority of the Secretary of Agriculture.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Weather Bureau,
Washington, D. C., October 4, 1892.

Sir: I have the honor to transmit herewith a paper entitled "The Diurnal Variation of Barometric Pressure," which has been prepared by Dr. Frank N. Cole, and to recommend its publication as Weather Bureau Bulletin No. 6.

Very respectfully,

Mark W. Harrington,
Chief of Weather Bureau.

Hon. J. M. Rusk,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

University of Michigan,
Ann Arbor, Mich., July 26, 1892.

Sir: I have the honor to submit herewith my Report on the Diurnal Variation of Barometric Pressure.

Very respectfully,

Frank N. Cole.

Mark W. Harrington,
Chief of Weather Bureau.

THE DIURNAL VARIATION OF BAROMETRIC PRESSURE.

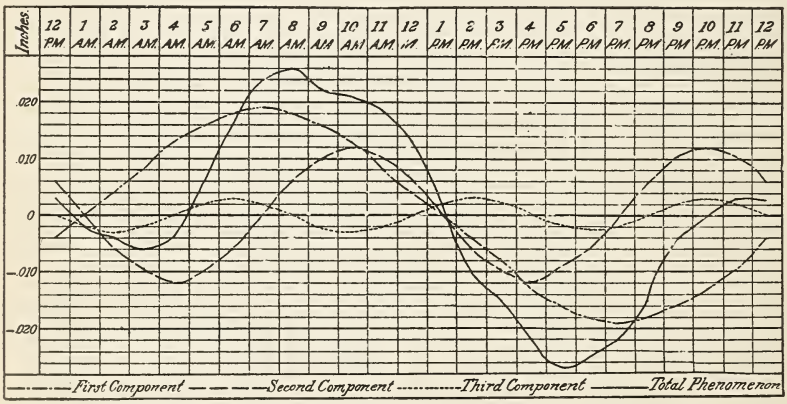
The daily variation of atmospheric pressure on the earth's surface is one of the most regular of atmospheric phenomena. As is well known, the barometric oscillation attains, except in a few localities, two maxima and two minima every twenty-four hours, the minima occurring between 2 and 4 o'clock of the early morning and afternoon, and maxima between 8 and 11 of the forenoon and evening. On the open sea in the tropics, where the disturbing effect of a land surface is eliminated and the daily variation in temperature reduced to a minimum, the barometric curve is almost perfectly symmetrical, presenting nearly equal maxima and minima at equal intervals of six hours. On land, however, and particularly in the interior of continents, the symmetry is considerably diminished, the maxima and minima are no longer equal, the day variation exceeds that of the night, and the intervals between the maxima and minima differ measurably.

Despite the regular character of the phenomenon, the determination of the physical causes producing it presents a problem of extreme difficulty. If the older method of regarding the barometric oscillation as a single phenomenon is adopted, it seems at first sight possible to account for the afternoon minimum as a direct result of the temperature maximum preceding it by one to two hours, and the consequent ascent of the heated atmosphere. Similarly, the morning maximum might be connected with the early morning temperature minimum, although obvious difficulties at once present themselves here. But it is an insurmountable objection to the theory that it can neither account for the night variation nor for that on the ocean surface in the tropics, which goes on with undiminished amplitude under a daily range of temperature of only two or three degrees.

On the other hand the method of harmonic analysis, *i. e.*, the resolution of the barometric oscillation into its harmonic constituents, promises material assistance in the solution of the problem of the physical cause. It is found that the barometric oscillation consists in the main of two components with periods of 24 and of 12 hours, respectively. Of these, the daily component is decidedly irregular in both phase and amplitude, and is undoubtedly due, at least in a large part, to local conditions. It nearly disappears on the tropical ocean, but occurs everywhere on the land with a large amplitude, which increases toward the centers of the continents and attains its maxi-

mum values in mountain valleys. The second (bi-daily) component, on the contrary, presents the utmost regularity in both phase and amplitude. It is apparently entirely independent of local conditions taking place over the entire earth, at least as far as latitude 60°, with a nearly mathematically uniform phase and a constant amplitude diminishing slowly as the latitude increases. Besides these two components there are others of higher orders, which, however, constitute only a very small part (in the mean perhaps one-eighth) of the whole. Of these, the third component (period 8 hours) seems from its regular character to represent a physical reality. Whether this is true of the others remains to be established.

The accompanying figure represents the first three component curves of barometric pressure, together with the actual barometric curve, for New York City for the month of June for the four years 1888–1891. The amplitudes of the first three components in inches are .019, .012, .003; their first maxima occur at, approximately, 7 a. m., 10 a. m., and 6 a. m.



Component curves of barometric pressure, New York City.

It is a fundamental question whether the process of harmonic analysis, as applied to the barometric variation, has an actual physical meaning. The component oscillations are usually computed from monthly means, any temporary irregularities thus disappearing in the mean. It may be observed that all those variations which have the same period, and only those, will be collected in the analysis into a single component, and that there is no method at present applicable for the separation of a component into further parts.

It seems to be generally agreed among meteorologists that the first (daily) and second (bi-daily) components are physical realities due to distinct causes. The first component is certainly due to such daily causes as the variation in temperature with its single maximum, land

and sea breezes, precipitation, frost, dew, and the general daily phenomena which are connected with the topography of the particular region.

The second component is an entirely different matter. We have here an oscillation with a period of 12 hours nearly uniform over the entire globe as far as latitude 60°, with a phase which moves with the greatest regularity forward in summer and backward in winter, through a range of about an hour. It is in form a perfect analogy to the solar tide. But it is, of course, impossible to suppose with some of the early meteorologists, that it is in any way gravitational. It is believed by Hann and other eminent authorities to be due, in some not as yet wholly determined way, to the sun's rádiant energy absorbed in the upper atmosphere. Hann has shown that the amplitude of this component, at least in the lower latitudes, has a maximum in December corresponding to the earth's perihelion. The difficulty with the component is, of course, to account for the night maximum and minimum. One cannot avoid recurring again and again to its tidal character. It has even been suggested that it is of cosmical origin, perhaps due to electro-magnetic causes.

If we accept the second component as physical, it is difficult to reject the higher components. Nevertheless, a natural hesitation is felt in supposing oscillations with periods of $\frac{24}{4}$, $\frac{24}{5}$, etc., hours to have a real existence. Mathematically, these periods are present to several higher orders, in winter perhaps seven or eight. The only criteria available for distinguishing the real from the imaginary components are the regularity of the former and their coincidence with other physical phenomena. From this standpoint the third component must certainly be regarded as real. This component resembles greatly the second. Although very small in the mean, it is extremely regular and uniform over the whole earth. Its amplitude has a minimum at each equinox, a large maximum in winter and a smaller one in summer. Besides this, the third component reverses its phase at the equinoxes, *i. e.*, its maxima in summer fall at the hours of the minima in winter. It seems certain that this component is connected in some way with the annual march of the sun, and is of the same general character as the second in regard to its moving cause.

The fourth component also shows a very noticeable regularity in both amplitude and phase, although much less so than the third. This component has a nearly constant amplitude from the vernal to the autumnal equinox, increasing about threefold in winter. The rapid and considerable change of its phase from month to month, while proceeding with great uniformity over the earth, makes it difficult to determine in many cases whether the change is a progression or a regression, and the difficulty is increased by the smallness of the amplitude in summer, which may decidedly affect the accuracy of

the calculation of the phase. A satisfactory treatment of the fourth component would require its determination for smaller intervals than a month. Probably fifteen days would be a convenient interval. From the data available it would seem that the fourth component is, like the preceding ones, a physical reality.

Tables I to VI give the amplitudes and phases of the first four components of barometric pressure computed from the monthly means for periods of two to four years, ending December 31, 1891, for the six cities, Boston, New York, Philadelphia, Chicago, Saint Louis, and Denver. To these are added the averages for Greenwich, England, for the 20 years, 1854 to 1873.*

NOTE ON THE METHOD EMPLOYED IN THE COMPUTATION OF THE HARMONIC COMPONENTS.

The computations follow the method given by Strachey in the proceedings of the Royal Society of London, vol. 42, p. 61, except that I find it more convenient to use the form

$$P_1 \cos. (x - \mu_1) + P_2 \cos. (2x - 2\mu_2) + P_3 \cos. (3x - 3\mu_3) + \ldots\ldots$$

than the form

$$P_1 \sin. (x - A_1) + P_2 \sin. (2x - A_2) + P_3 \sin. (3x - A_3) + \ldots\ldots$$

Otherwise my tables are precisely like those of Strachey, as given on pp. 75 and 77 of the article referred to.

In some cases it is impossible to decide whether the phase has moved forward or backward. These cases are marked with an *. The mean barometer is noted for each month, except in the case of Chicago, where the location of the station was changed in 1890.

The computations in Table I are for standard time; to reduce to local time add 4° to each angle. Tables II to VI are computed for local time.

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* Taken from the British report on Harmonic Analysis of Temperature and Pressure at British observatories. London, 1891.

TABLE I.—*Harmonic analysis for pressure.*

BAROGRAPH READINGS, BOSTON, MASS. SUMMARY, 1888-1891.

	Year.	P_1	P_2	P_3	P_4	μ_1	μ_2	μ_3	μ_4
						° ′	° ′	° ′	° ′
January, 29.9165.........	1889.....	.0101	.0021	.0017	.0007	124 06	109 20	5 25	35 36
	1890.....	.0236	.0174	.0075	.0045	37 29	135 06	30 00	64 21
	1891.....	.0090	.0090	.0073	.0044	28 27	135 59	27 28	50 16
	Mean ...	.0142	.0111	.0055	.0032	63 21	126 48	20 58	50 04
February, 29.9350........	1889. ...	.0090	.0019	.0014	.0007	107 30	140 03	2 43	75 45
	1890.....	.0114	.0149	.0066	.0009	6 38	131 00	27 34	77 58
	1891.....	.0106	.0153	.0046	.0005	65 02	136 45	31 09	67 30
	Mean ...	.0103	.0107	.0042	.0007	59 43	135 56	20 29	73 44
March, 29.8471...........	1889.....	.0107	.0011	.0010	.0005	127 01	136 41	5 42	— 2 03
	1890.....	.0278	.0188	.0026	.0007	59 08	137 39	19 46	10 13
	1891.....	.0152	.0174	.0014	.0013	99 13	133 34	15 00	12 48
	Mean ...	.0179	.0124	.0017	.0008	95 07	135 58	13 29	6 59*
April, 29.8831............	1888.....	.0163	.0106	.0014	.0024	67 36	135 11	30 00	19 11
	1889.....	.0117	.0078	.0008	.0007	82 52	138 12	75 00	17 14
	1890.....	.0194	.0182	.0019	.0017	87 29	139 46	95 01	8 46
	1891.....	.0178	.0158	.0023	.0028	31 06	140 38	105 50	23 46
	Mean ...	.0163	.0131	.0016	.0019	67 16	138 27	76 28	16 74
May, 29.8499.............	1888.....	.0136	.0133	.0012	.0010	66 33	149 31	94 41	6 35
	1889.....	.0183	.0133	.0026	.0004	93 18	130 14	67 44	22 30
	1890.....	.0253	.0149	.0026	.0013	76 11	141 14	95 40	8 10
	1891.....	.0273	.0149	.0017	.0007	74 43	139 07	91 35	33 54
	Mean ...	.0211	.0141	.0020	.0008	77 41	140 01	87 25	17 47
June, 29.8074............	1888.....	.0188	.0117	.0020	.0005	86 10	145 56	84 41	12 16
	1889†....	.0250	.0119	.0033	.0004	87 35	136 17	81 19	—28 29*
	1890.....	.0178	.0100	.0033	.0006	82 34	140 59	90 48	1 49
	1891.....	.0196	.0108	.0024	.0011	103 23	144 13	91 38	16 15
	Mean ...	.0203	.0111	.0027	.0006	89 55	141 51	87 06	2 58
July, 29.8693............	1888.....	.0161	.0100	.0006	.0009	103 11	142 09	62 22	2 11
	1890.....	.0171	.0117	.0034	.0006	80 15	139 45	89 37	18 00
	1891.....	.0107	.0092	.0013	.0007	108 13	141 28	77 55	6 55
	Mean ...	.0146	.0103	.0018	.0007	97 13	141 07	76 38	9 02
August, 29.8687..........	1888.....	.0088	.0122	.0010	.0016	85 16	139 55	82 59	— 2 31
	1889‡....	.0107	.0119	.0018	.0007	91 51	142 10	90 44	— 8 10
	1890.....	.0056	.0110	.0026	.0005	85 18	138 19	80 01	10 58
	1891.....	.0137	.0110	.0017	.0001	107 23	141 20	93 55	0 00
	Mean ...	.0097	.0115	.0018	.0007	92 27	140 26	86 55	0 04*
September, 29.9596	1888.....	.0132	.0109	.0003	.0008	20 25	134 28	21 09	23 37
	1889.....	.0080	.0127	.0010	.0010	78 02	137 43	17 59	15 48
	1890.....	.0133	.0141	.0012	.0006	79 45	139 16	6 51	9 52
	1891.....	.0184	.0167	.0008	.0007	93 41	141 42	28 16	4 46
	Mean ...	.0132	.0136	.0008	.0008	68 03	138 17	18 34	13 31
October, 29.8301	1888.....	.0127	.0166	.0032	.0001	29 54	125 42	8 07	22 30
	1889.....	.0097	.0149	.0023	.0008	52 52	131 38	12 31	48 43
	1890.....	.0048	.0152	.0023	.0000	79 00	119 27	19 25	0 00
	1891.....	.0054	.0143	.0025	.0004	56 30	139 09	20 40	— 2 20
	Mean ...	.0081	.0152	.0026	.0003	54 34	128 59	15 11	17 13*
November, 29.9417.......	1888.....	.0219	.0151	.0028	.0006	69 00	136 23	21 21	56 11
	1889.....	.0057	.0150	.0063	.0004	66 43	128 32	24 03	42 40
	1890.....	.0052	.0182	.0058	.0016	47 03	119 07	18 09	58 03
	1891.....	.0149	.0166	.0061	.0010	87 58	130 28	20 05	69 16
	Mean ...	.0119	.0162	.0052	.0009	67 41	128 37	20 54	56 32
December, 29.9066	1888.....	.0126	.0130	.0066	.0020	43 44	129 20	24 18	51 36
	1889.....	.0124	.0167	.0066	.0051	36 59	124 02	24 09	53 07
	1890.....	.0078	.0152	.0070	.0031	167 50	129 09	22 00	55 06
	1891.....	.0163	.0141	.0094	.0043	115 50	127 19	21 27	53 26
	Mean ...	.0123	.0147	.0074	.0036	91 06	127 27	22 59	53 19
4 years, 29.8845..........	....	.0142	.0128	.0031	.0012	77 01	135 19	45 35	26 32

† 1-18. ‡ 10-31.

TABLE II.—*Harmonic analysis for pressure.*

BAROGRAPH READINGS, NEW YORK, N. Y. SUMMARY, 1888–1891.

	Year.	P_1	P_2	P_3	P_4	μ_1	μ_2	μ_3	μ_4
						° ′	° ′	° ′	° ′
January, 29.8844	1889.....	.0144	.0182	.0074	.0042	125 48	137 44	20 59	57 29
	1890.....	.0203	.0195	.0077	.0043	43 24	138 48	29 31	66 08
	1891.....	.0056	.0178	.0085	.0019	2 01	145 31	31 13	52 58
	Mean ...	.0134	.0185	.0079	.0035	57 04	140 41	27 14	58 52
February, 29.9035........	1889.....	.0125	.0224	.0046	.0012	96 02	138 49	32 15	58 05
	1890.....	.0151	.0141	.0024	.0013	81 51	144 15	35 52	95 36
	1891.....	.0160	.0174	.0048	.0018	88 08	147 53	33 23	90 12
	Mean ...	.0145	.0180	.0039	.0014	88 40	143 39	33 50	81 18
March, 29.8031...........	1889.....	.0196	.0187	.0022	.0013	102 12	145 42	31 52	24 36
	1890.....	.0206	.0149	.0008	.0017	37 42	140 27	26 19	0 09
	1891.....	.0195	.0135	.0023	.0023	108 36	151 40	18 22	10 57
	Mean ...	.0199	.0157	.0018	.0018	82 50	145 56	25 31	11 54
April, 29.8442............	1888.....	.0205	.0148	.0015	.0009	84 12	148 59	67 09	28 52
	1889.....	.0203	.0195	.0012	.0012	91 56	144 04	104 25	60 45*
	1890.....	.0302	.0182	.0020	.0006	94 00	146 27	112 09	16 55
	1891.....	.0216	.0155	.0021	.0020	82 14	149 20	113 16	28 32
	Mean ...	.0231	.0170	.0017	.0012	88 05	147 12	99 15	11 16
May, 29.7967	1888.....	.0157	.0167	.0013	.0011	112 19	147 23	121 00	27 48
	1889.....	.0201	.0146	.0033	.0006	106 00	139 57	92 35	22 07
	1890.....	.0223	.0157	.0039	.0014	74 23	148 24	103 34	17 21
	1891.....	.0188	.0146	.0029	.0013	80 07	150 24	116 23	9 33
	Mean ...	.0192	.0154	.0028	.0011	93 12	146 32	108 23	19 12
June, 29.7754	1888.....	.0215	.0111	.0027	.0015	104 26	153 13	103 35	27 08
	1889†....	.0172	.0135	.0015	.0010	95 36	139 42	80 14	16 48
	1890.....	.0173	.0113	.0044	.0001	100 39	152 28	91 34	46 38
	1891.....	.0194	.0117	.0033	.0014	109 00	150 50	99 09	14 54
	Mean ...	.0188	.0119	.0030	.0010	102 25	149 03	93 38	23 52
July, 29.8750.............	1888.....	.0200	.0118	.0013	.0006	118 14	155 23	109 30	23 30
	1890.....	.0090	.0107	.0032	.0014	88 30	146 24	97 48	36 03
	1891.....	.0115	.0125	.0025	.0008	124 08	151 41	103 43	7 25
	Mean ...	.0135	.0117	.0023	.0009	110 17	151 09	103 40	22 19
August, 29.8736	1888.....	.0184	.0143	.0023	.0009	118 45	153 33	99 36	51 59
	1889‡....	.0141	.0117	.0013	.0003	109 31	157 13	115 50	80 47
	1890.....	.0058	.0100	.0014	.0013	106 08	148 36	95 41	45 13
	1891.....	.0119	.0111	.0012	.0006	105 35	153 51	101 19	57 11
	Mean ...	.0125	.0118	.0015	.0008	110 00	153 18	103 06	58 47
September, 29.9132	1888.....	.0085	.0159	.0019	.0012	130 00	154 07	45 00	21 20
	1889.....	.0124	.0125	.0014	.0012	75 33	144 35	61 00	7 47
	1890.....	.0170	.0141	.0010	.0003	96 07	145 18	10 26	42 46
	1891.....	.0165	.0160	.0014	.0015	96 43	150 37	—14 00	22 54
	Mean ...	.0136	.0146	.0014	.0010	99 36	140 39	25 36	23 42
October, 29.7894	1888.....	.0156	.0154	.0025	.0002	82 46	137 52	24 02	40 45
	1889.....	.0159	.0126	.0031	.0005	61 35	139 20	16 55	80 02
	1890.....	.0128	.0147	.0028	.0012	97 13	138 37	19 38	66 57
	1891.....	.0138	.0159	.0028	.0009	80 14	146 31	22 46	78 44
	Mean ...	.0145	.0146	.0028	.0007	80 27	140 35	20 50	66 37
November, 29.9021.......	1888.....	.0184	.0150	.0033	.0017	82 11	139 04	23 35	65 19
	1889.....	.0178	.0146	.0058	.0033	87 24	136 39	28 47	75 27
	1890.....	.0132	.0136	.0035	.0013	47 01	134 58	17 35	50 47
	1891.....	.0230	.0167	.0048	.0019	69 21	142 34	25 43	63 05
	Mean ...	.0181	.0150	.0043	.0020	71 29	138 19	23 55	63 39
December, 29.8974	1888.....	.0060	.0186	.0052	.0031	107 02	136 12	26 41	65 35
	1889.....	.0208	.0173	.0101	.0037	48 50	132 27	26 17	49 22
	1890.....	.0162	.0140	.0060	.0027	104 52	139 26	32 32	54 59
	1891.....	.0244	.0151	.0048	.0029	89 55	142 39	32 38	61 31
	Mean ...	.0168	.0162	.0065	.0031	87 40	137 41	29 32	57 52

† 1–18. ‡ 8–31.

TABLE III.—*Harmonic analysis for pressure.*

BAROGRAPH READINGS, PHILADELPHIA, PA. SUMMARY, 1888-1891.

	Year.	P_1	P_2	P_3	P_4	μ_1	μ_2	μ_3	μ_4
						° ′	° ′	° ′	° ′
January, 29.9905	1889	.0152	.0159	.0065	.0042	112 54	140 49	28 47	55 41
	1890	.0111	.0212	.0078	.0032	57 27	142 02	38 11	60 14
	1891	.0045	.0198	.0093	.0033	143 47	140 34	35 26	64 31
	Mean	.0103	.0190	.0079	.0036	104 43	141 08	34 08	60 09
February, 30.0004	1889	.0180	.0163	.0048	.0016	95 53	141 30	31 33	74 40
	1890	.0115	.0175	.0045	.0011	94 38	144 15	36 53	88 04
	1891	.0170	.0205	.0041	.0002	87 07	147 09	33 31	32 45
	Mean	.0155	.0181	.0045	.0010	92 33	144 18	33 59	65 10
March, 29.8989	1889	.0178	.0163	.0027	.0019	98 31	144 37	16 44	27 16
	1890	.0189	.0189	.0014	.0004	61 12	146 08	29 08	15 38
	1891	.0226	.0190	.0003	.0014	112 23	149 08	11 14	3 40
	Mean	.0198	.0181	.0015	.0012	90 42	146 38	19 02	15 31
April, 29.9131	1889	.0237	.0172	.0005	.0017	90 58	144 49	24 41	23 01
	1890	.0298	.0189	.0039	.0011	103 01	147 55	124 46*	53 37
	1891	.0265	.0172	.0014	.0011	95 08	150 38	90 58	28 00
	Mean	.0267	.0178	.0019	.0013	96 22	147 47	80 08	34 53
May, 29.8897	1888	.0219	.0170	.0021	.0024	104 07	150 15	102 25	18 49
	1890	.0145	.0101	.0027	.0010	94 41	150 37	101 21	87 57*
	1891	.0209	.0158	.0022	.0009	93 04	151 10	101 14	12 17
	Mean	.0191	.0163	.0023	.0014	97 17	150 43	101 40	9 41
June, 29.8623	1890	.0226	.0145	.0039	.0003	106 41	156 34	95 10	64 27
	1891	.0251	.0139	.0014	.0009	100 15	147 03	95 51	94 52*
	Mean	.0238	.0142	.0026	.0006	103 28	151 48	95 30	79 38
July, 29.9162	1888	.0217	.0126	.0014	.0006	112 50	156 25	134 20*	— 5 11*
	1890	.0159	.0127	.0028	.0007	101 55	150 10	94 14	+17 14
	1891	.0179	.0121	.0020	.0004	119 43	150 55	98 51	2 20
	Mean	.0185	.0125	.0021	.0006	111 29	152 30	109 08	4 48
August, 29.9115	1888	.0226	.0139	.0012	.0004	110 23	152 23	58 56	30 45
	1889†	.0157	.0158	.0020	.0006	117 38	157 18	107 51	3 15
	1890	.0147	.0136	.0014	.0007	108 46	147 50	90 00	38 48
	1891	.0153	.0131	.0026	.0011	107 20	154 10	101 06	44 02
	Mean	.0171	.0141	.0018	.0007	111 02	152 55	89 28	29 12
September, 29.9813	1888	.0110	.0163	.0017	.0008	101 47	146 00	41 14	13 06
	1889	.0107	.0130	.0015	.0007	91 45	149 16	53 03	30 45
	1890	.0167	.0165	.0003	.0012	100 26	148 14	68 51	26 17
	1891	.0169	.0173	.0006	.0003	104 12	149 07	36 09	48 14
	Mean	.0138	.0158	.0010	.0007	99 32	148 09	49 49	29 35
October, 29.8844	1888	.0144	.0172	.0023	.0006	94 29	146 05	20 22	43 21
	1889	.0147	.0178	.0019	.0006	96 25	140 32	23 51	23 52
	1890	.0131	.0108	.0038	.0009	119 47	137 03	29 18	42 48
	1891	.0138	.0186	.0032	.0006	97 42	141 01	29 11	40 14
	Mean	.0140	.0176	.0028	.0007	102 06	141 10	25 40	37 84
November, 30.0012	1888	.0138	.0149	.0050	.0012	77 37	142 01	28 56	63 15
	1889	.0134	.0173	.0061	.0021	83 13	140 22	26 19	64 13
	1890	.0147	.0170	.0059	.0021	90 31	141 58	30 40	57 59
	1891	.0209	.0213	.0057	.0016	68 12	137 43	26 46	54 13
	Mean	.0157	.0176	.0057	.0017	79 53	140 31	28 11	59 55
December, 30.0093	1888	.0103	.0161	.0051	.0030	129 20	138 51	37 42	60 57
	1889	.0199	.0195	.0082	.0037	75 03	140 02	30 58	58 56
	1890	.0232	.0160	.0075	.0036	110 36	145 48	30 53	59 09
	1891	.0226	.0187	.0069	.0032	100 14	142 55	36 48	62 08
	Mean	.0190	.0176	.0069	.0034	103 48	141 54	34 05	60 17
4 years		.01777	.01657	.00342	.00141	99 25	146 38	58 24	40 32

†7-31.

TABLE IV.—*Harmonic analysis for pressure.*

BAROGRAPH READINGS, CHICAGO, ILL. SUMMARY, 1888-1891.

	Year.	P_1	P_2	P_3	P_4	μ_1	μ_2	μ_3	μ_4
						° ′	° ′	° ′	° ′
January	1889	.0079	.0123	.0060	.0033	−2 25	133 54	28 37	61 06
	1890	.0134	.0133	.0066	.0044	157 54	146 18	30 06	69 51
	1891	.0140	.0150	.0061	.0031	34 37	134 21	30 49	53 14
	Mean	.0117	.0135	.0062	.0036	75 52	138 11	29 51	61 24
February	1889	.0249	.0086	.0039	.0023	73 25	149 44	32 44	22 37
	1890	.0189	.0118	.0058	.0014	64 23	137 11	33 37	−12 30
	1891	.0167	.0165	.0032	.0007	57 08	142 52	36 16	−0 14
	Mean	.0202	.0123	.0043	.0015	64 59	143 16	34 12	3 18
March	1889	.0126	.0143	.0009	.0008	133 19	146 53	46 02	26 05
	1890	.0099	.0131	.0018	.0014	151 30	145 12	21 16	25 20
	1891	.0132	.0108	.0010	.0029	44 03	150 03	39 15	2 19
	Mean	.0119	.0127	.0012	.0017	109 17	147 23	35 31	17 55
April	1888	.0235	.0110	.0006	.0004	105 26	141 46	10 39	14 01
	1889	.0263	.0100	.0001	.0007	146 04	135 19	38 39	8 46
	1890	.0147	.0146	.0013	.0006	141 51	146 07	96 50	23 33
	1891	.0126	.0119	.0019	.0013	128 00	139 21	102 00	66 14*
	Mean	.0193	.0119	.0010	.0007	130 20	140 38	62 02	18 08*
May	1888	.0146	.0085	.0035	.0006	124 19	150 28	98 09	−20 00*
	1889	.0168	.0114	.0020	.0009	114 03	140 28	97 45	11 02
	1890	.0138	.0106	.0030	.0010	124 03	149 54	95 33	5 24
	1891	.0275	.0124	.0019	.0002	127 56	149 50	99 51	14 02
	Mean	.0182	.0107	.0026	.0007	122 35	147 40	97 49	2 37*
June	1888	.0222	.0123	.0034	.0012	122 52	155 12	108 18	−18 51*
	1889	.0122	.0103	.0023	.0004	139 42	145 31	98 09	−3 27*
	1890	.0178	.0109	.0025	.0005	126 42	149 08	99 21	11 46*
	1891	.0211	.0122	.0030	.0006	127 18	151 58	88 59	−19 18*
	Mean	.0183	.0114	.0028	.0007	129 08	150 27	101 12	−7 27*
July	1888	.0206	.0092	.0033	.0006	120 18	160 23	114 55	−9 15*
	1890	.0175	.0095	.0018	.0015	128 08	159 06	103 00	−0 41*
	1891	.0202	.0088	.0012	.0002	137 36	148 53	100 02	−11 20*
	Mean	.0194	.0092	.0021	.0010	128 41	156 07	105 59	−7 05*
August	1888	.0162	.0098	.0007	.0008	120 41	149 01	69 31	22 46
	1889†	.0260	.0114	.0013	.0008	115 08	142 42	83 39	26 05
	1890	.0161	.0111	.0013	.0008	131 42	152 08	104 31	−2 46*
	1891	.0167	.0112	.0006	.0017	111 26	145 29	82 11	−16 49*
	Mean	.0187	.0109	.0010	.0010	119 44	147 29	84 58	7 19*
September	1888	.0180	.0129	.0004	.0011	123 41	145 38	37 11	22 50
	1889	.0181	.0141	.0016	.0007	118 40	147 13	95 15	−14 00*
	1890	.0188	.0121	.0013	.0009	123 13	149 59	34 47	−13 41*
	1891	.0254	.0133	.0010	.0002	111 51	149 49	57 35	17 30
	Mean	.0201	.0131	.0011	.0007	119 21	148 09	56 12	3 10*
October	1888	.0107	.0104	.0033	.0001	102 39	135 42	15 42	−9 16*
	1889	.0163	.0115	.0018	.0012	133 14	142 46	29 21	−17 46*
	1890	.0037	.0112	.0017	.0009	102 12	140 15	36 55	27 56
	1891	.0134	.0124	.0022	.0005	71 19	139 02	38 23	4 09
	Mean	.0110	.0114	.0022	.0007	102 21	139 26	30 05	1 16*
November	1888	.0153	.0118	.0049	.0011	90 24	132 30	24 04	65 13
	1889	.0003	.0090	.0046	.0023	14 04	134 49	29 37	65 13
	1890	.0025	.0102	.0044	.0014	86 28	136 20	32 17	60 51
	1891	.0101	.0108	.0052	.0007	33 34	136 49	27 02	65 26
	Mean	.0070	.0104	.0048	.0014	56 07	135 07	28 15	64 10
December	1888	.0099	.0107	.0065	.0027	70 59	136 40	34 31	68 12
	1889	.0135	.0098	.0081	.0039	159 22	141 57	34 55	60 51
	1890	.0093	.0123	.0068	.0017	93 37	136 29	35 08	63 09
	1891	.0182	.0140	.0069	.0035	86 54	137 04	27 59	62 43
	Mean	.0127	.0117	.0071	.0029	102 43	138 02	33 08	64 44
4 years		.01572	.01160	.00303	.00138	105 06	144 20	58 16	17 27

† 8-31.

TABLE V.—*Harmonic analysis for pressure.*

BAROGRAPH READINGS, SAINT LOUIS, MO. SUMMARY, 1888-1891.

	Year.	P_1	P_2	P_3	P_4	μ_1	μ_2	μ_3	μ_4
						° ′	° ′	° ′	° ′
January, 29.5097	1889.....	.0158	.0170	.0070	.0041	143 31	137 49	33 15	59 37
	1890.....	.0300	.0149	.0053	.0021	111 54	149 41	40 59	73 41
	1891.....	.0117	.0129	.0086	.0056	74 06	140 40	32 53	63 35
	Mean ...	.0192	.0149	.0070	.0039	109 50	142 43	35 42	65 38
February, 29.4947	1889.....	.0223	.0162	.0050	.0030	92 26	153 15	29 56	77 32
	1890.....	.0213	.0170	.0066	.0024	97 03	144 39	34 11	78 34
	1891.....	.0305	.0194	.0055	.0019	108 45	145 04	41 07	76 52
	Mean ...	.0247	.0175	.0057	.0024	99 25	144 29	35 05	77 39
March, 29.4426	1889.....	.0155	.0194	.0010	.0017	137 19	146 02	85 17	78 29
	1890.....	.0284	.0182	.0021	.0012	115 14	149 01	33 53	100 49*
	1891.....	.0103	.0188	.0014	.0005	72 11	150 03	31 01	84 37
	Mean ...	.0181	.0188	.0015	.0011	108 15	148 22	50 04	87 57
April, 29.4580	1888.....	.0380	.0172	.0008	.0018	99 35	155 23	66 36	25 11
	1889.....	.0263	.0150	.0014	.0013	110 40	146 25	41 54	20 33
	1890.....	.0167	.0159	.0030	.0011	120 53	151 15	95 30	8 48
	1891.....	.0242	.0166	.0020	.0019	104 55	150 10	100 04	62 07*
	Mean ...	.0263	.0162	.0018	.0015	109 01	150 48	76 01	6 40
May, 29.3844	1888.....	.0231	.0129	.0008	.0006	105 50	147 39	87 22	69 59
	1889.....	.0259	.0129	.0030	.0006	119 14	156 16	110 29	83 42
	1890.....	.0253	.0133	.0039	.0014	116 42	154 50	97 51	61 32
	1891.....	.0347	.0137	.0035	.0009	112 02	153 17	94 51	114 09*
	Mean ...	.0272	.0132	.0028	.0009	113 27	153 00	97 38	82 20
June, 29.3669	1888.....	.0267	.0119	.0014	.0012	110 01	148 29	106 37	60 11
	1889.....	.0213	.0147	.0017	.0009	104 53	148 11	105 00	109 44
	1890.....	.0280	.0153	.0029	.0006	114 48	157 02	94 16	85 56
	1891.....	.0276	.0110	.0057	.0014	117 27	154 02	102 26	90 50
	Mean ...	.0259	.0132	.0029	.0010	111 47	151 56	102 01	86 40
July, 29.4347	1888.....	.0310	.0124	.0023	.0012	106 05	150 13	95 54	116 09*
	1890.....	.0345	.0159	.0011	.0012	114 20	158 56	74 45	73 53
	1891.....	.0281	.0117	.0038	.0011	117 45	155 26	103 22	50 42
	Mean ...	.0312	.0133	.0024	.0012	112 43	154 52	91 20	72 45
August, 29.4545	1888.....	.0251	.0161	.0010	.0007	115 10	148 22	50 04	39 58
	1889†....	.0301	.0146	.0017	.0012	123 34	156 54	103 14	46 24
	1890.....	.0267	.0155	.0014	.0009	126 04	159 11	95 04	94 12*
	1891.....	.0236	.0139	.0026	.0009	102 58	148 15	84 32	62 28
	Mean ...	.0264	.0150	.0017	.0009	119 26	153 10	83 13	60 45
September, 29.4987	1888.....	.0288	.0149	.0008	.0011	120 02	148 13	48 11	87 39
	1889.....	.0222	.0156	.0014	.0005	119 52	144 31	41 54	68 12
	1890.....	.0261	.0154	.0007	.0013	109 34	148 54	54 26	68 16
	1891.....	.0371	.0180	.0006	.0014	104 14	147 34	1 28	69 42
	Mean ...	.0285	.0160	.0009	.0011	113 25	147 18	36 30	73 27
October, 29.4751	1888.....	.0240	.0160	.0040	.0011	103 30	143 21	33 59	62 28
	1889.....	.0196	.0141	.0045	.0012	114 50	145 03	36 49	63 02
	1890.....	.0167	.0154	.0030	.0014	145 49	143 23	20 19	53 33
	1891.....	.0253	.0176	.0028	.0009	104 35	144 20	33 23	79 38
	Mean ...	.0214	.0158	.0036	.0011	117 11	144 02	31 07	64 40
November, 29.5191	1888.....	.0182	.0161	.0055	.0021	100 18	142 25	32 10	59 30
	1889.....	.0111	.0115	.0060	.0034	117 07	138 49	37 07	69 46
	1890.....	.0188	.0135	.0050	.0021	129 17	140 20	35 33	64 43
	1891.....	.0176	.0149	.0066	.0019	125 03	144 21	26 26	63 54
	Mean ...	.0164	.0140	.0058	.0024	117 56	141 29	32 51	64 28
December, 29.5147	1888.....	.0082	.0151	.0079	.0025	126 14	137 18	40 41	72 42
	1889.....	.0216	.0163	.0052	.0045	110 34	140 01	31 42	60 40
	1890.....	.0153	.0171	.0085	.0034	119 45	144 19	31 50	56 52
	1891.....	.0199	.0162	.0081	.0035	76 38	141 50	17 49	71 09
	Mean ...	.0162	.0162	.0074	.0035	108 18	140 52	30 30	65 21

† 8–31.

TABLE VI.—*Harmonic analysis for pressure.*

BAROGRAPH READINGS, DENVER, COLO. SUMMARY, 1889–1891.

	Year.	P_1	P_2	P_3	P_4	μ_1	μ_2	μ_3	μ_4
						° ′	° ′	° ′	° ′
January, 24.7216	1890	.0065	.0172	.0078	.0053	77 42	142 25	27 06	57 16
	1891	.0045	.0149	.0038	.0052	70 29	146 17	33 30	61 11
	Mean	.0055	.0160	.0058	.0052	74 05	144 21	30 18	59 13
February, 24.6004	1890	.0270	.0192	.0014	.0008	40 18	139 48	21 57	61 16
	1891	.0053	.0134	.0025	.0024	169 17	129 31	47 17	85 11
	Mean	.0161	.0163	.0034	.0016	89 47	134 39	34 37	73 13
March, 24.6625	1890	.0195	.0188	.0019	.0006	90 54	137 32	13 32	65 51
	1891	.0102	.0135	.0019	.0011	27 36	142 03	33 30	75 24
	Mean	.0178	.0161	.0019	.0008	59 15	139 47	23 31	70 37
April, 24.7490	1890	.0258	.0196	.0030	.0018	81 51	148 49	103 06	49 34
	1891	.0209	.0141	.0017	.0009	43 20	144 32	105 00	51 19
	Mean	.0233	.0168	.0023	.0013	62 35	146 40	104 03	50 26
May, 24.7442	1890	.0361	.0141	.0047	.0017	66 41	141 33	92 50	71 53
	1891	.0261	.0157	.0026	.0008	67 32	144 49	90 00	62 43
	Mean	.0311	.0149	.0036	.0012	67 06	143 11	91 25	67 18
June, 24.7211	1890	.0402	.0140	.0050	.0011	75 57	143 39	94 14	43 45
	1891	.0332	.0139	.0044	.0007	79 11	143 51	90 18	50 36
	Mean	.0367	.0139	.0047	.0009	77 34	143 45	92 16	47 10
July, 24.8553	1890	.0220	.0119	.0037	.0002	80 47	151 37	102 13	65 14
	1891	.0226	.0121	.0030	.0007	98 55	147 36	96 42	61 22
	Mean	.0223	.0120	.0033	.0004	89 51	149 36	99 27	63 18
August, 24.8687	1890	.0127	.0152	.0025	.0007	77 47	146 12	101 58	55 02
	1891	.0115	.0153	.0007	.0014	83 20	146 51	105 00	61 30
	Mean	.0121	.0152	.0016	.0010	80 33	146 31	103 29	58 16
September, 24.8326	1889	.0295	.0127	.0010	.0019	81 52	138 32	63 46	58 54
	1890	.0240	.0107	.0014	.0006	82 25	145 30	110 19	60 00
	1891	.0261	.0196	.0014	.0012	84 07	147 23	67 37	52 08
	Mean	.0265	.0143	.0013	.0012	82 48	143 48	80 34	57 01
October, 24.8374	1889	.0201	.0138	.0012	.0021	85 39	135 21	19 28	53 54
	1890	.0230	.0153	.0008	.0026	68 09	136 16	73 44	51 27
	1891	.0271	.0220	.0042	.0016	61 57	139 44	36 20	55 58
	Mean	.0234	.0170	.0031	.0021	71 55	137 07	43 11	53 46
November, 24.8278	1889	.0116	.0126	.0060	.0015	62 56	130 06	18 54	48 37
	1890	.0132	.0127	.0016	.0021	55 58	137 40	16 44	63 19
	1891	.0120	.0192	.0061	.0021	16 06	142 15	32 48	61 56
	Mean	.0123	.0148	.0045	.0019	45 00	136 40	22 49	57 57
December, 24.7128	1889	.0116	.0169	.0052	.0045	54 08	128 13	19 33	52 36
	1890	.0120	.0159	.0051	.0036	58 07	140 08	30 00	60 00
	1891	.0132	.0180	.0081	.0038	300 32	138 57	31 08	67 23
	Mean	.0123	.0159	.0061	.0040	137 36	135 46	26 54	60 00

TABLE VII.—*Harmonic analysis for pressure.*

BAROGRAPH READINGS, GREENWICH, ENGLAND, 1854-1873.

Month.	P_1.	μ_1.	P_2.	μ_2.	P_3.	μ_3.	P_4.	μ_4.	Mean pressure P.
		°		°		°		°	
January	.0099	229	.0081	147	.0045	34	.0026	64	29.729
February	.0074	124	.0098	153	.0035	39	.0011	86	29.832
March	.0063	79	.0107	156	.0015	44	.0012	19	29.722
April	.0080	92	.0102	156	.0009	104	.0010	40	29.804
May	.0089	61	.0089	156	.0018	98	.0009	46	29.777
June	.0074	77	.0086	158	.0023	101	.0009	56	29.829
July	.0061	88	.0083	160	.0022	103	.0010	49	29.809
August	.0058	84	.0099	157	.0016	107	.0011	44	29.799
September	.0059	124	.0109	153	.0011	31	.0015	35	29.787
October	.0071	37	.0106	149	.0028	30	.0009	45	29.720
November	.0060	250	.0089	148	.0035	32	.0012	66	29.763
December	.0076	123	.0081	149	.0046	33	.0027	62	29.791
Mean for 20 years	.0072	114	.0094	154	.0025	63	.0013	51	29.780

NOTE.—The mean values of μ_1 are of doubtful accuracy, particularly for the months of January and November.

THE FIRST THREE COMPONENTS.

The phase of the first component exhibits a considerable degree of regularity. For 85 stations cited by Hann the maximum of the first component occurred at 61 between 4 a. m. and 8 a. m., and at 35 between 4 a. m. and 6 a. m., coinciding therefore, approximately, with the time of minimum temperature. For the 6 American stations tabulated above, excluding Denver, the extreme limits for the means are 3.48 a. m. and 8.40 a. m. If Chicago is omitted the upper limit reduces to 8 a. m. All the stations show a marked progression of the phase from winter to summer, possibly due to the forward motion of the epoch of maximum temperature. Undoubtedly the unsymmetrical form of the daily temperature curve and the approach and recession of its maximum and minimum have a powerful effect on the phase of the first barometric component. Great irregularities in the phase occur only in the winter months, when there is a decided tendency to a retrogression as far as midnight. The greatest deviation from the normal was in Denver in December, 1891, when the maximum occurred at 8 p. m. The twenty-year series for Greenwich show a much greater variation than those for the American stations, together with a retrogression of the phase in summer instead of a progression.

It is suggested by Hann that the first component may be in reality made up of two portions, one universal and resembling in this respect the second component, the other local. It should be possible to settle this question by a comparison of observations from a number of neighboring stations with as different local conditions as possible.

A comparison of the tables for Boston, New York, and Philadelphia furnishes interesting results in regard to the amplitude of the first component. The months of October, 1889, 1890, and 1891 show an amplitude much below the normal, preceded by a similar

depression in August of 1890 and September of 1889. The depression continued in 1889 and 1890 through November, and in 1890 through December, and January of 1891. In the latter month it extended to New York and Philadelphia, and in February it had disappeared in all three cities. The remaining components were not affected during this time. A study of the local influences producing so considerable an effect would certainly repay the labor spent. It is from an examination of such abnormalities that the true causes of the normal phenomenon can be best determined.

The mean yearly amplitudes of the first component for the six American stations are: Boston, .0128; New York, .0165; Philadelphia, .0178; Chicago, .0157; Saint Louis, .0259; and Denver, .0200, increasing on the whole, as is seen, toward the interior of the continent. These amplitudes are remarkably larger than those for European stations: Greenwich, .0072; Paris, .0070; Leipzig, .0060; Vienna, .0081; Geneva, .0100, and approach the values characteristic of mountain regions.

Of the six American stations (excluding Denver on account of its elevation and surroundings), Saint Louis exhibits the greatest regularity, and Boston the greatest irregularity in respect to the amplitude of the first component. Boston, in fact, seems to be a border city, and it would be of great value to compare its first component for a series of years with that of Saint John or of Halifax.

The mean yearly range of the time of first maximum and the mean amplitude of the second component for each of the six stations and for Greenwich are given in the following table, the hours being all a. m.:

TABLE VIII.—*Mean annual amplitude and epoch of first component.*

Station.	μ_2	P_2
	Hours.	
Boston	8.40 to 9.40	.0128
New York	9.20 to 10.12	.0150
Philadelphia	9.24 to 10.12	.0166
Chicago	9.12 to 10.24	.0116
Saint Louis	9.28 to 10.16	.0154
Denver	8.56 to 9.56	.0153
Greenwich	9.48 to 10.40	.0094

The mean first maximum accordingly varies by almost exactly an hour in the course of the year for all the seven localities in entirely different situations and with considerable difference in climate; and the same regularity occurs in fact everywhere. As in the case of the first component the amplitude for Greenwich is much less than that for the American stations. This is, however, here due, in part, to the fact that the amplitude of the second component diminishes as the latitude increases over the whole earth. For Vienna, 3° south of Greenwich, the amplitude is .0122.

The following table shows the monthly means of the amplitude for the six stations:

TABLE IX.—*Mean monthly amplitude of first component.*

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Boston	.0111	.0107	.0124	.0131	.0141	.0111	.0103	.0115	.0136	.0152	.0162	.0147
New York	.0185	.0180	.0157	.0170	.0154	.0119	.0117	.0118	.0146	.0146	.0150	.0162
Philadelphia	.0191	.0181	.0181	.0178	.0163	.0142	.0125	.0141	.0158	.0176	.0176	.0176
Chicago	.0135	.0123	.0127	.0119	.0107	.0114	.0192	.0109	.0131	.0114	.0104	.0117
Saint Louis	.0149	.0175	.0188	.0162	.0132	.0132	.0133	.0150	.0160	.0158	.0140	.0162
Denver	.0160	.0163	.0161	.0168	.0149	.0139	.0120	.0152	.0143	.0170	.0148	.0159
Mean	.0155	.0155	.0156	.0155	.0141	.0126	.0115	.0131	.0146	.0153	.0147	.0154
Mean omitting Boston	.0164	.0164	.0163	.0160	.0141	.0129	.0117	.0134	.0148	.0153	.0143	.0153

The winter maximum and summer minimum discovered by Hann, and attributed by him to the earth's perihelion and aphelion, appear clearly in each of the cases as well as in the mean. The maxima at the equinoxes are also distinguishable, but are confused in the spring with the winter maximum. A mean is given at the foot of the table for five of the stations, Boston being excluded on account of the abnormal character of the amplitude for the first three months of 1889, when it sunk to $\frac{1}{5}-\frac{1}{10}$ of its normal value. So great an irregularity does not occur at any other of the six stations, not even at Denver, where the first component has an amplitude ranging from .005 to .037. The exceptional character of the barometric oscillation at Boston deserves, as already stated, a special investigation. It will be noticed in Table I that in the month referred to above the amplitudes of the second, third, and fourth components were all greatly reduced below the normal, and that none of these components were affected at New York.

The regular and universal march of the amplitude of the third component is shown in the following table:

TABLE X.—*Mean monthly amplitude of the third component.*

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Boston	.0055	.0042	.0017	.0016	.0020	.0027	.0018	.0018	.0008	.0026	.0052	.0074
New York	.0079	.0039	.0018	.0017	.0028	.0030	.0023	.0015	.0014	.0028	.0043	.0065
Philadelphia	.0079	.0045	.0015	.0019	.0023	.0026	.0021	.0018	.0010	.0028	.0057	.0069
Chicago	.0062	.0043	.0012	.0010	.0026	.0028	.0021	.0010	.0011	.0022	.0048	.0071
Saint Louis	.0070	.0057	.0015	.0018	.0028	.0029	.0024	.0017	.0009	.0036	.0058	.0074
Denver	.0058	.0034	.0019	.0023	.0036	.0047	.0033	.0016	.0013	.0031	.0045	.0061
Greenwich	.0045	.0035	.0015	.0009	.0018	.0023	.0022	.0016	.0011	.0028	.0035	.0046
Calcutta	.0077	.0055	.0020	.0019	.0041	.0038	.0035	.0032	.0007	.0030	.0052	.0073
Melbourne	.0050	.0026	.0009	.0028	.0055	.0059	.0054	.0053	.0030	.0002	.0030	.0040

In the northern hemisphere a large maximum occurs in December–January and a smaller one in May–June, while the reverse is the case

in the southern. In all cases a strongly marked minimum occurs at each equinox. The amplitudes of the several stations show a most remarkable agreement, greater than that for the second component. A similar uniformity of phase appears in the annexed table for the first maximum (the hour is reckoned from local midnight).

TABLE XI.—*Epoch of the first maximum of third component.*

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	Hrs.	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*
Boston	1.40	1.38	1.10	5.22	6.06	6.04	5.22	6.09	1.29	1.16	1.40	1.48
New York	1.49	2.15	1.41	6.37	7.13	6.14	6.34	6.32	1.42	1.23	1.36	1.58
Philadelphia	2.16	2.16	1.16	5.36	6.46	6.22	7.16	5.58	3.19	1.43	1.53	2.16
Chicago	1.59	2.17	2.22	4.08	6.31	6.45	7.04	5.40	3.45	2.00	1.53	2.12
Saint Louis	2.23	2.20	3.20	5.04	6.30	6.48	6.05	5.33	2.26	2.04	2.11	2.02
Denver	2.01	2.18	1.34	6.57	6.06	6.09	6.38	6.54	5.22	2.53	1.31	1.48
Greenwich	2.16	2.36	2.56	6.56	6.32	6.44	6.52	7.08	2.04	2.00	2.08	2.12

It is seen at once that the epoch of the maximum is nearly constant between the equinoxes, but changes at the latter abruptly. The means for each station from October to February and from April to August are:

TABLE XII.—*Means from October to February and April to August.*

Station.	Oct. to Feb.	Apr. to Aug.	Difference.
	Hrs.	*Hrs.*	*Hrs.*
Boston	1.36	5.48	4.12
New York	1.48	6.38	3.50
Philadelphia	2.05	6.24	4.19
Chicago	2.04	6.01	3.57
Saint Louis	2.12	6.00	3.48
Denver	2.08	6.33	4.25
Greenwich	2.14	6.50	4.36
Mean	2.01	6.17	4.16

It appears that the third component with its period of eight hours changes its phase for all stations by almost exactly four hours at each equinox, in other words, that its phase is exactly reversed at these two points. In view of these facts it seems established that the third component is a direct result of the annual motion in latitude of the sun; that, representing this cause, it is complementary to the second component, the two together furnishing nearly the whole of that portion of the barometric oscillation which is due to universal, as distinguished from local, causes. The minima in the amplitude of the third component are evidently unreal. They appear in the monthly averages only on account of the reversal of phase, which must, of course, produce precisely this effect. In reality, the amplitude has one maximum in winter and one minimum in summer.

The determination of an adequate physical cause for the fourth component is a matter of much greater difficulty. Nevertheless, its amplitude and phase show a great uniformity. The amplitude is

always a maximum in winter and diminishes rapidly to a fairly constant value, often approaching the vanishing point in summer. Its mean ratio to the amplitude of the second component is as follows, (yearly means): Boston, 12 : 31; New York, 15 : 33; Philadelphia, 14 : 34; Chicago, 14 : 30; Saint Louis, 18 : 36; Denver, 18 : 35; Greenwich, 13 : 25, *i. e.*, about 1 : 2. The epoch of the first (or second) maximum from month to month is:

TABLE XIII.—*Epoch of the first maximum.*

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
	Hrs.	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*	*Hrs.*
Boston	3.36	5.11	6.44	7.41	7.21	6.28	6.52	6.16	7.06	7.25	4.02	3.49
New York	3.55	5.25	6.47	6.45	7.17	7.35	7.29	3.55	7.35	4.26	4.14	3.51
Philadelphia	4.01	4.21	7.02	8.19	6.39	5.18	6.19	7.57	7.58	8.30	4.00	4.01
Chicago	4.06	6.13	7.12	7.13	6.10	5.30	5.32	6.29	6.13	6.05	4.17	4.19
Saint Louis	4.22	5.10	5.52	6.27	5.29	5.47	4.51	4.03	4.54	4.19	4.18	4.21
Denver	3.57	4.53	4.42	3.22	4.29	3.09	4.13	3.53	3.48	3.35	3.52	4.00
Greenwich	4.16	5.44	7.16	7.40	3.04	3.44	3.16	2.56	2.20	3.00	4.24	4.08

A difficulty is experienced here in determining whether the epoch in passing from month to month has gone forward or backward. This can only be met by calculation for shorter periods of time. The uncertainty is very considerable. For example, in case of several of the stations it is impossible to decide at what point in the fall the epoch returns to the first quadrant, or whether it returns at all.

DISTRIBUTION OF BAROMETRIC PRESSURE AT NEW YORK, N. Y.

Table XIV shows the distribution of the barometric pressure for every .05 inch for every month from April, 1888, to December, 1891, at New York, together with the *á priori* distribution as deduced from the probability curve $y = \frac{h}{\sqrt{\pi}} e^{-h^2 x^2}$.

TABLE XIV.—*Frequency of barometric heights at New York, N. Y., from hourly barograph readings.*

Base number, 28+ inches. JANUARY. Mean 29.884. Above 539. Below 461. $h = .229$.

	.70	.75	.80	.85	.90	.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75
1889						8	6	4	8	24	6	5	11	27	18	21	18	24	25	23	57	28
1890													4	6	4	9	14	21	28	47	33	41
1891	3	3	1	1	2	2	3	2	4	13	9	11	7	9	7	13	14	19	34	31	34	42
Sum	3	3	1	1	2	10	9	6	12	37	15	16	22	42	29	43	46	64	87	101	124	111
Per mille	1	1	0	0	1	4	4	3	5	17	7	7	10	19	13	19	21	29	39	45	56	50
Probable				1	0	1	2	1	4	5	6	10	12	17	21	28	32	40	45	51	57	60
Difference	1	1	0	−1	1	3	2	2	1	12	1	−3	−2	2	−8	−9	−11	−11	−6	−6	−1	−10

	1.80	1.85	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25	2.30	2.35	2.40	2.45	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85
1889	36	21	45	95	31	19	37	38	38	17	18	23	13									
1890	56	38	35	33	45	31	32	46	43	24	38	30	36	38	2	6	4					
1891	52	90	102	40	62	32	13	23	35	18	13											
Sum	144	149	182	168	138	82	82	107	116	59	69	53	49	38	2	6	4					
Per mille	65	67	82	75	62	37	37	48	52	26	31	24	22	17	1	3	2					
Probable	63	65	63	62	58	54	47	42	34	29	24	18	15	10	7	6	4	2	2	0	1	1
Difference	2	2	19	13	4	−17	−10	6	18	−3	7	6	7	7	−6	−3	−2	−2	−2	0	−1	−1

TABLE XIV.—*Frequency of barometric heights, &c.*—Continued.

FEBRUARY. Mean 29.903. Above 495. Below 505. $h = .214$.

	.80	.85	.90	.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85
1889	......	......	......	......	......	......	......	......	9	13	7	5	4	13	28	63	49	33	28	42	25	34
1890	......	......	......	......	......	......	......	......	......	2	14	12	6	11	17	23	32	25	29	32	42	67
1891	......	......	......	......	......	......	......	......	5	17	17	14	18	28	32	34	25	26	23	22	46	35
Sum	......	......	......	......	......	......	......	......	14	32	38	31	28	52	77	120	106	84	80	96	113	136
Per mille	......	......	......	......	......	......	......	......	7	16	19	15	14	26	38	60	53	42	40	48	56	67
Probable	1	0	1	1	2	2	5	5	7	10	14	17	21	26	31	37	43	47	53	56	58	60
Difference	−1	0	−1	−1	−2	−2	−5	−5	0	6	5	−2	−7	0	7	23	10	−5	−13	−8	−2	7

	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25	2.30	2.35	2.40	2.45	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85	2.90	2.95
1889	32	26	23	12	20	21	9	15	29	23	30	22	21	23	9	4	......	......	......	......	......	......
1890	83	61	44	28	19	20	16	15	26	39	9	......	......	......	......	......	......	......	......	......	......	......
1891	27	37	30	28	39	41	27	27	37	11	10	12	4	......	......	......	......	......	......	......	......	......
Sum	142	124	97	68	78	82	52	57	92	73	49	34	25	23	9	4	......	......	......	......	......	......
Per mille	70	62	48	34	39	41	26	28	46	36	24	17	12	11	4	2	......	......	......	......	......	......
Probable	60	58	56	53	48	43	38	31	27	22	18	13	11	7	6	4	3	1	2	1	0	1
Difference	10	4	−8	−19	−9	−2	−12	−3	19	14	6	4	1	4	−2	−2	−3	−1	−2	−1	0	−1

TABLE XIV.—*Frequency of barometric heights, &c.*—Continued.

MARCH. Mean 29.803. Above 536. Below 464. $h = .251$.

	.85	.90	.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75
1889	......	......	4	26	4	8	7	15	13	11	4	33	21	35	59	47	75	55	47
1890	......	......	......	......	......	1	3	5	5	9	21	28	40	39	33	32	34	39	58
1891	......	......	......	......	......	......	......	......	5	4	11	17	17	19	16	23	30	35	40
Sum	......	......	4	26	4	9	10	20	23	24	36	78	78	93	108	102	139	129	145
Per mille	......	......	2	12	2	4	4	9	10	11	16	35	35	42	48	45	62	58	65
Probable	1	0	1	2	2	4	6	9	12	17	23	29	35	44	51	58	64	68	70
Difference	— 1	0	1	10	0	0	— 2	0	— 2	— 6	— 7	6	0	— 2	— 3	—13	— 2	—10	— 5

	1.80	1.85	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25	2.30	2.35	2.40	2.45	2.50	2.55	2.60	2.65	2.70
1889	56	62	35	32	18	15	23	15	12	1	10	1	......	......	......	......	......	......	......
1890	51	32	50	60	31	33	45	21	16	26	27	5	......	......	......	......	......	......	......
1891	49	65	97	74	55	36	43	37	33	16	9	13	......	......	......	......	......	......	......
Sum	156	159	182	166	104	84	111	73	61	43	46	19	......	......	......	......	......	......	......
Per mille	70	71	82	74	47	38	50	33	28	19	21	8	......	......	......	......	......	......	......
Probable	70	68	64	55	51	44	37	30	24	17	12	10	6	4	3	2	1	0	1
Difference	0	3	18	19	— 4	— 6	13	3	4	2	9	— 2	— 6	— 4	— 3	— 2	— 1	0	— 1

TABLE XIV.—*Frequency of barometric heights, &c.*—Continued.

APRIL. Mean 29.844. Above 507. Below 493. $h=.274$.

	.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80
1888	......	......	......	......	......	......	......	4	5	2	3	6	16	22	54	91	82	44
1889	......	4	9	6	5	9	5	12	29	21	10	28	31	58	33	40	55	67
1890	......	......	......	......	......	......	2	7	13	17	17	8	8	41	32	39	58	33
1891	......	......	......	......	10	5	4	11	31	36	18	8	8	32	61	70	80	49
Sum	......	4	9	6	15	14	11	34	78	76	48	50	63	153	180	240	275	193
Per mille	......	1	3	2	5	5	4	12	27	26	17	17	22	53	62	83	95	67
Probable	1	0	1	2	2	5	7	10	15	21	28	35	45	55	62	69	74	77
Difference	−1	1	2	0	3	0	−3	2	12	5	−11	−18	−23	−2	0	14	21	−10

	1.85	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25	2.30	2.35	2.40	2.45	2.50	2.55	2.60	2.65
1888	41	56	44	30	41	24	34	54	31	29	7	......	......	......	......	......	......
1889	74	39	29	34	24	37	47	6	8	......	......	......	......	......	......	......	......
1890	44	75	52	49	42	42	67	41	15	6	7	5	......	......	......	......	......
1891	54	67	38	39	23	14	10	16	12	15	9	......	......	......	......	......	......
Sum	213	237	163	152	130	117	158	117	66	50	23	5	......	......	......	......	......
Per mille	74	82	57	53	45	41	55	41	23	17	8	2	......	......	......	......	......
Probable	76	74	67	61	52	42	34	27	19	14	9	6	5	2	1	1	1
Difference	−2	8	−10	−8	−7	−1	21	14	4	3	−1	−4	−5	−2	−1	−1	−1

TABLE XIV.—*Frequency of barometric heights, &c.*—Continued.

MAY. Mean 29.796. Above 489. Below 511. $h = .437$.

	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25	2.30
1888	......	......	......	......	......	8	40	33	83	142	102	51	43	46	62	50	58	26	......	......	......	......
1889	......	......	......	6	28	21	56	74	63	96	76	111	82	35	17	23	12	38	6	......	......	......
1890	......	......	3	34	16	20	34	46	76	78	82	83	81	39	68	49	20	15	......	......	......	......
1891	......	......	......	......	5	8	26	27	41	99	137	97	108	57	56	27	13	4	10	20	9	......
Sum	......	......	3	40	49	57	156	180	263	415	397	342	314	177	203	149	103	83	16	20	9	......
Per mille	......	......	1	13	16	19	52	60	88	139	133	115	106	59	68	50	35	28	5	7	3	......
Probable	1	2	4	7	18	31	49	70	93	111	122	120	109	90	68	44	29	15	9	4	1	1
Difference	−1	−2	−3	6	−2	−12	3	−10	−5	28	11	−5	−3	−31	0	6	6	13	−4	3	2	−1

JUNE. Mean 29.770. Above 506. Below 494. $h = .438$.

	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25	2.30
1–18, 1888	......	......	......	......	......	4	25	13	35	55	58	48	26	29	51	57	22	9	......	......	......	......	......
1889	......	......	......	5	25	13	11	13	16	32	49	46	67	55	37	47	16	......	......	......	......	......	......
1890	......	......	......	......	......	......	......	3	25	74	43	47	54	35	34	31	31	28	20	7	......	......	......
1891	......	......	......	......	......	......	9	27	22	25	49	45	48	37	53	95	22	......	......	......	......	......	......
A. Sum	......	......	......	5	25	17	45	56	98	186	199	186	195	156	175	230	91	37	20	7	......	......	......
19–30, 1888	......	......	......	......	......	......	23	43	31	39	27	24	16	7	5	16	38	19	......	......	......	......	......
1890	......	......	......	......	......	......	......	12	62	46	57	29	16	37	15	14	......	......	......	......	......	......	......
1891	......	......	......	......	......	6	20	46	59	48	75	28	6	......	......	......	......	......	......	......	......	......	......
B. Sum	......	......	......	......	......	6	43	101	152	133	159	81	38	44	20	30	38	19	......	......	......	......	......
$\frac{3}{4}$ A + $\frac{2}{3}$ B	......	......	......	4	19	17	63	109	175	228	255	193	172	146	145	192	94	41	15	5	......	......	......
Per mille	......	......	......	2	10	9	34	58	93	122	136	103	92	78	77	102	50	22	8	3	......	......	......
Probable	1	1	3	6	13	24	39	60	82	104	118	122	116	100	78	55	36	21	12	5	3	0	1
Difference	−1	−1	−3	−4	−3	−15	−5	−2	11	18	18	−19	−24	−22	−1	47	14	1	−4	−2	−3	0	−1

TABLE XIV.—*Frequency of barometric heights, &c.*—Continued.

JULY. Mean 29.875. Above 566. Below 434. $h = .429$.

	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25	2.30	2.35	2.40
1888	......	......	......	4	11	18	6	8	16	30	63	77	83	98	85	149	58	19	14	5	......	......	......
1890	......	......	......	......	......	22	30	28	28	53	85	78	126	113	65	57	42	17	......	......	......	......	......
1891	......	......	......	......	6	29	45	63	80	143	77	90	45	55	18	38	45	10	......	......	......	......	......
Sum	......	......	......	4	17	69	81	99	124	226	225	245	254	266	168	244	145	46	14	5	......	......	......
Per mille	......	......	......	2	8	31	36	44	56	101	101	110	113	119	75	109	65	21	6	2	......	......	......
Probable	1	1	3	7	13	23	40	57	80	101	114	120	114	101	80	57	40	23	13	7	3	1	1
Difference	− 1	− 1	− 3	− 5	− 5	8	− 4	−13	−24	0	−13	−10	− 1	18	− 5	52	25	− 2	− 7	− 5	− 3	− 1	− 1

AUGUST. Mean 29.874. Above 559. Below 441. $h = .466$.

	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25	2.30	2.35
1–7, 1888	......	......	......	......	......	......	......	7	24	44	36	23	29	5	......	......	......	......	......	......	......
1890	......	......	......	......	......	......	......	......	8	2	10	28	57	53	10	......	......	......	......	......	......
1891	......	......	......	10	18	5	7	12	8	26	21	33	28	......	......	......	......	......	......	......	......
A. Sum	......	......	......	10	18	5	7	19	40	72	67	84	114	58	10	......	......	......	......	......	......
8–31, 1888	......	......	5	4	1	2	2	3	3	5	45	73	95	71	121	70	36	27	13	......	......
1889	......	......	......	7	12	15	13	46	61	75	44	98	107	43	31	21	3	......	......	......	......
1890	......	......	6	4	6	29	32	55	57	89	72	83	72	43	19	9	......	......	......	......	......
1891	......	......	......	12	8	13	56	61	138	100	68	59	35	24	2	......	......	......	......	......	......
B. Sum	......	......	11	27	27	59	103	165	259	269	229	313	309	181	173	100	39	27	13	......	......
$\frac{7}{83}$ A + $\frac{6}{31}$ B	......	......	2	6	7	12	20	33	53	54	49	67	68	39	34	19	7	5	2	......	......
Per mille	......	......	4	13	15	25	42	69	111	113	103	140	143	82	71	40	15	10	4	......	......
Probable	1	1	5	10	20	34	55	81	107	123	131	123	106	79	55	35	18	10	4	1	1
Difference	− 1	− 1	− 1	3	− 5	− 9	−13	−12	4	−10	−28	17	37	3	16	5	− 3	0	0	− 1	− 1

TABLE XIV.—*Frequency of barometric heights, &c.*—Continued.

SEPTEMBER. Mean 29.912. Above 555. Below 445. $h = .447$.

	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85
1888	......	......	5	10	3	6	7	14	5	44	43	93	77
1889	11	7	9	6	14	17	9	6	35	79	32	45	96
1890	......	......	......	......	......	......	......	12	19	41	40	77	72
1891	......	......	......	......	......	......	3	5	14	24	25	56	108
Sum	11	7	14	16	17	23	19	37	73	188	140	271	353
Per mille	4	3	5	6	6	8	7	13	25	65	49	94	122
Probable	......	......	1	1	3	6	14	24	42	62	87	108	122
Difference	4	3	4	5	3	2	−7	−11	−17	3	−38	−14	0

	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25	2.30	2.35	2.40	2.45	2.50	2.55
1888	100	84	76	46	19	24	9	5	6	3	11	14	11	5
1889	121	139	38	25	31	......	......	......	......	......	......	......	......	......
1890	97	92	120	62	71	17	......	......	......	......	......	......	......	......
1891	154	99	72	72	39	42	7	......	......	......	......	......	......	......
Sum	472	414	306	205	160	83	16	5	6	3	11	14	11	5
Per mille	164	144	106	71	56	29	6	2	2	1	4	5	4	2
Probable	123	117	98	74	51	32	19	9	4	2	1	......	......	......
Difference	41	27	8	−3	5	−3	−13	−7	−2	−1	3	5	4	2

TABLE XIV.—*Frequency of barometric heights, &c.*—Continued.

OCTOBER. Mean 29.789. Above 558. Below 442. $h = .306$.

	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70
1888	......	......	......	......	3	10	16	33	18	11	47	55	36	43	72
1889	......	......	......	......	......	......	......	10	13	12	13	10	21	39	80
1890	......	......	6	5	4	35	17	39	26	29	48	46	53	44	63
1891	......	......	......	......	......	......	......	......	......	19	37	57	46	44	48
Sum	......	......	6	5	7	45	33	82	57	71	145	168	156	170	263
Per mille	......	......	2	2	2	15	11	28	19	24	49	56	52	57	88
Probable	1	0	2	2	5	7	12	18	25	34	45	56	68	76	83
Difference	— 1	0	0	0	— 3	8	— 1	10	— 6	—10	4	0	—16	—19	5

	1.75	1.80	1.85	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25	2.30	2.35	2.40	2.45	2.50
1888	59	80	53	34	43	23	23	45	20	20	......	......	......	......	......	......
1889	76	117	110	77	70	21	12	19	25	13	......	......	......	......	......	......
1890	79	50	36	21	23	21	48	36	15	......	......	......	......	......	......	......
1891	66	64	54	61	32	38	24	42	18	52	24	16	2	......	......	......
Sum	280	311	253	193	174	103	107	142	78	85	24	16	2	......	......	......
Per mille	94	105	85	65	58	35	36	47	26	29	8	5	1	......	......	......
Probable	85	85	80	73	62	52	39	31	21	15	9	7	3	2	1	1
Difference	9	20	5	— 8	— 4	—17	— 3	16	5	14	— 1	— 2	— 2	— 2	— 1	— 1

TABLE XIV.—*Frequency of barometric heights, &c.*—Continued.

NOVEMBER. Mean 29.902. Above 541. Below 459. $h = .242$.

	.90	.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60	1.65	1.70	1.75	1.80	1.85
1888	......	......	7	13	3	4	2	9	7	5	13	11	33	37	38	33	30	21	17	29
1889	......	......	......	......	......	11	10	12	10	4	6	17	33	38	25	41	31	24	22	29
1890	......	......	......	......	......	......	......	3	2	4	14	3	16	42	48	36	42	39	49	65
1891	......	......	......	3	2	2	2	4	4	7	6	14	14	20	19	20	21	43	73	69
Sum	......	......	7	16	5	17	14	28	23	20	39	45	96	137	130	130	124	127	161	192
Per mille	......	......	2	6	2	6	5	10	8	7	14	16	33	48	45	45	43	44	56	67
Probable	1	0	1	0	3	3	5	7	10	13	18	24	30	36	43	51	57	62	66	67
Difference	−1	0	1	6	−1	3	0	3	−2	−6	−4	−8	3	12	2	−6	−14	−18	−10	0

	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25	2.30	2.35	2.40	2.45	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85
1888	25	33	31	42	63	28	33	28	53	26	15	17	7	6	1	......	......	......	......	......
1889	60	92	97	46	15	8	16	10	9	19	27	8	......	......	......	......	......	......	......	......
1890	104	53	70	52	56	22	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1891	38	39	40	47	54	39	24	16	15	26	19	14	16	6	4	......	......	......	......	......
Sum	227	217	238	187	188	97	73	54	77	71	61	39	23	12	5	......	......	......	......	......
Per mille	79	75	83	65	65	34	25	19	27	25	21	14	8	4	2	......	......	......	......	......
Probable	68	66	62	57	52	44	36	30	25	19	13	10	7	6	3	2	1	1	0	1
Difference	11	9	21	8	13	−10	−11	−11	2	6	8	4	1	−2	−1	−2	−1	−1	0	−1

TABLE XIV.—*Frequency of barometric heights, &c.*—Continued.

DECEMBER. Mean 29.896. Above 551. Below 449. $h = .256$.

	.50	.55	.60	.65	.70	.75	.80	.85	.90	.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55	1.60
1888	1	3	1	2	......	1	2	1	2	2	1	2	2	2	2	4	14	15	15	19	16	33	35
1889	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	12	23	48	19	21	30	18	18
1890	......	......	......	......	......	......	......	......	......	......	......	......	3	2	1	2	4	4	3	5	4	1	18
1891	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	6	2	5	16	22	10	18	12
Sum	1	3	1	2	......	1	2	1	2	2	1	2	5	4	4	24	43	72	53	67	60	70	83
Per mille	0	1	0	1	......	0	1	0	1	1	0	1	2	1	1	8	14	24	18	23	20	24	28
Probable	......	......	......	......	......	......	......	......	......	1	0	1	2	2	4	6	8	13	17	22	30	36	45
Difference	0	1	0	1	......	0	1	0	1	0	0	0	0	— 1	— 3	2	6	11	1	1	—10	—12	—17

	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25	2.30	2.35	2.40	2.45	2.50	2.55	2.60	2.65	2.70	2.75	2.80
1888	42	50	39	55	80	48	33	38	30	33	24	22	30	17	24	4	......	......	......	......	......	......	......	......
1889	30	41	36	35	40	48	46	44	69	48	40	23	20	18	15	2	......	......	......	......	......	......	......	......
1890	27	54	52	77	45	66	55	59	96	40	23	28	32	14	3	3	4	2	1	10	6	......	......	......
1891	14	21	39	31	37	67	62	67	81	59	72	56	9	11	26	......	......	......	......	......	......	......	......	......
Sum	113	166	166	198	202	229	196	208	276	180	159	129	91	60	68	9	4	2	1	10	6	......	......	......
Per mille	38	56	56	67	68	77	66	70	93	60	53	43	31	20	23	3	1	1	0	3	2	......	......	......
Probable	52	60	66	69	72	71	69	65	58	51	44	35	28	22	17	11	8	6	4	1	2	1	0	1
Difference	—14	— 4	—10	— 2	— 4	6	— 3	5	35	9	9	8	3	— 2	6	— 8	— 7	— 5	— 4	2	0	— 1	0	— 1

TABLE XIV.—*Frequency of barometric heights, &c.*—Continued.

YEAR (in per milles). Mean 29.854. Above 527. Below 473. $h = .297$.

	.50	.55	.60	.65	.70	.75	.80	.85	.90	.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50	1.55
January	.....	.....	.....	.....	1	1	0	0	1	4	4	3	5	17	7	7	10	19	13	19	21	29
February	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7	16	19	15	14	26	38	60
March	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	12	2	4	4	9	10	11	16	35	35	42	48
April	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	3	2	5	5	4	12	27	26	17	17	22
May	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	13	16	19	52
June	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	10	9	34	58
July	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	8	31
August	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	13	15
September	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4	3	5	6	6	8	7
October	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	2	2	15	11	28	19	24	49	56
November	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	6	2	6	5	10	8	7	14	16	33	48
December	0	1	0	1	.....	0	1	0	1	1	0	1	2	1	1	8	14	24	18	23	20	24
Sums	0	1	0	1	1	1	1	0	2	7	19	15	17	35	36	74	88	144	168	197	302	450
Means	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	2	1	1	3	3	6	7	12	14	16	25	37
Probable	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	1	1	2	5	7	12	16	25	31	43
Difference	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	2	0	0	2	1	1	0	0	− 2	− 9	− 6	− 6

	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25	2.30	2.35	2.40	2.45	2.50	2.55	2.60	2.65
January	39	45	56	50	65	67	82	75	62	37	37	48	52	26	31	24	22	17	1	3	2	.....
February	53	42	40	48	56	67	70	62	48	34	39	41	26	28	46	36	24	17	12	11	4	2
March	45	62	58	65	70	71	82	74	47	38	50	33	28	19	21	8	.....	.....	.....	.....	.....	.....
April	53	62	83	95	67	74	82	57	53	45	41	55	41	23	17	8	2	.....	.....	.....	.....	.....
May	60	88	139	133	115	106	59	68	50	35	28	5	7	3	.....	.....	.....	.....	.....	.....	.....	.....
June	93	122	136	103	92	78	77	102	50	22	8	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
July	36	44	56	101	101	110	113	119	75	109	65	21	6	2	.....	.....	.....	.....	.....	.....	.....	.....
August	25	42	69	111	113	103	140	143	82	71	40	15	10	4	.....	.....	.....	.....	.....	.....	.....	.....
September	13	25	65	49	94	122	164	144	106	71	56	29	6	2	2	1	4	5	4	2	.....	.....
October	52	57	88	94	105	85	65	58	35	36	47	26	29	8	5	1	.....	.....	.....	.....	.....	.....
November	45	45	43	44	56	67	79	75	83	65	65	34	25	19	27	25	21	14	8	4	2	.....
December	28	38	56	56	67	68	77	66	70	93	60	53	43	31	20	23	3	1	1	0	3	2
Sums	542	672	889	949	1,001	1,018	1,090	1,043	761	656	536	363	273	165	169	126	76	54	26	20	11	4
Means	45	56	74	79	83	85	91	87	62	55	45	30	23	14	14	10	6	4	2	2	1	.....
Probable	52	64	72	79	82	83	80	74	64	55	43	34	25	18	12	8	5	2	2	1	1	.....
Difference	− 7	− 8	2	0	1	2	11	13	− 2	0	2	− 4	− 2	− 4	2	2	1	2	0	1	0	.....